



MAGNETIC PROPERTIES OF SPUTTERED PERMALLOY/MOLIBDENUM MULTILAYERS

M. Romera¹; M. Maicas¹; R. Ranchal²; D. Ciudad¹; E. López²; P. Sánchez¹

1. ISOM, Universidad Politécnica de Madrid, Madrid, Madrid, Spain.
2. Física de Materiales, Universidad Complutense de Madrid, Madrid, Madrid, Spain.



Samples characteristics

- The multilayers were grown by dc magnetron sputtering
- The anisotropy induced was controlled by the angle of incidence of the beam.
- The anisotropy was measured for a single Py layer (125 nm thick) obtaining an anisotropy constant of $K=1200$ J/m³ which corresponds to an exchange correlation length of 180 nm.

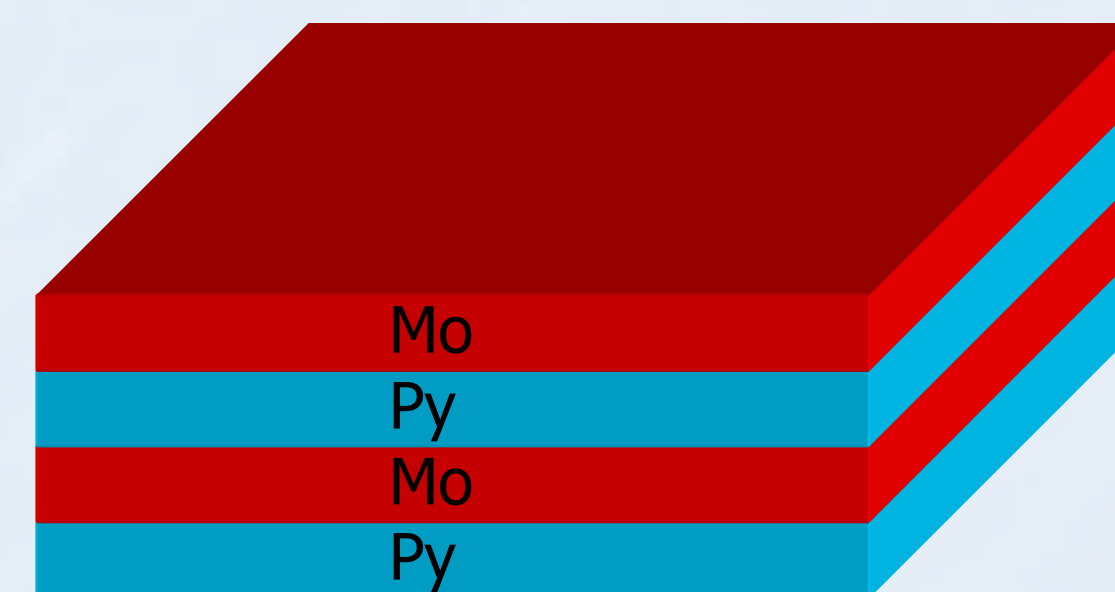


Fig 1: MFM measurements

Permeability and linearity control

- Permeability can be controlled by the relative thickness between layers with different anisotropy direction.

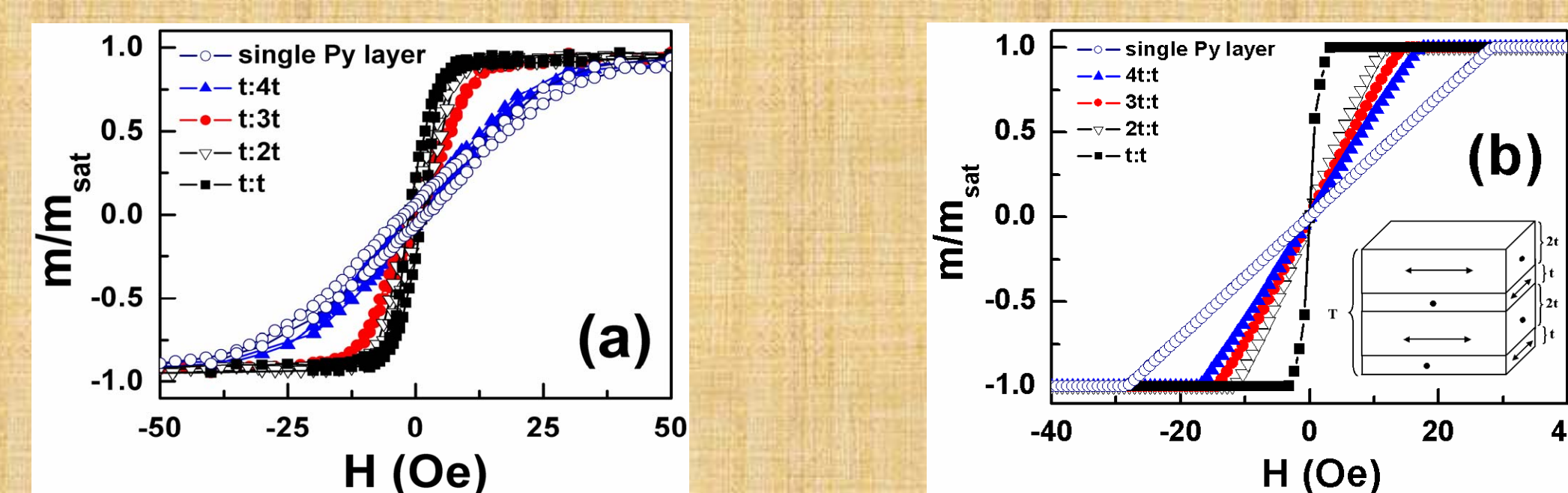


Figure 6. Hysteresis loops of Py multilayers with a total thickness of 150 nm and 4 layers with alternating perpendicular anisotropies and different relative thicknesses (t:t, t:2t, t:3t and t:4t), a) experimental and b) simulated.

- Linear hysteresis loops can be obtained by growing the sample with a large number of layers so the thickness of each single layer is much lower than the exchange correlation length.

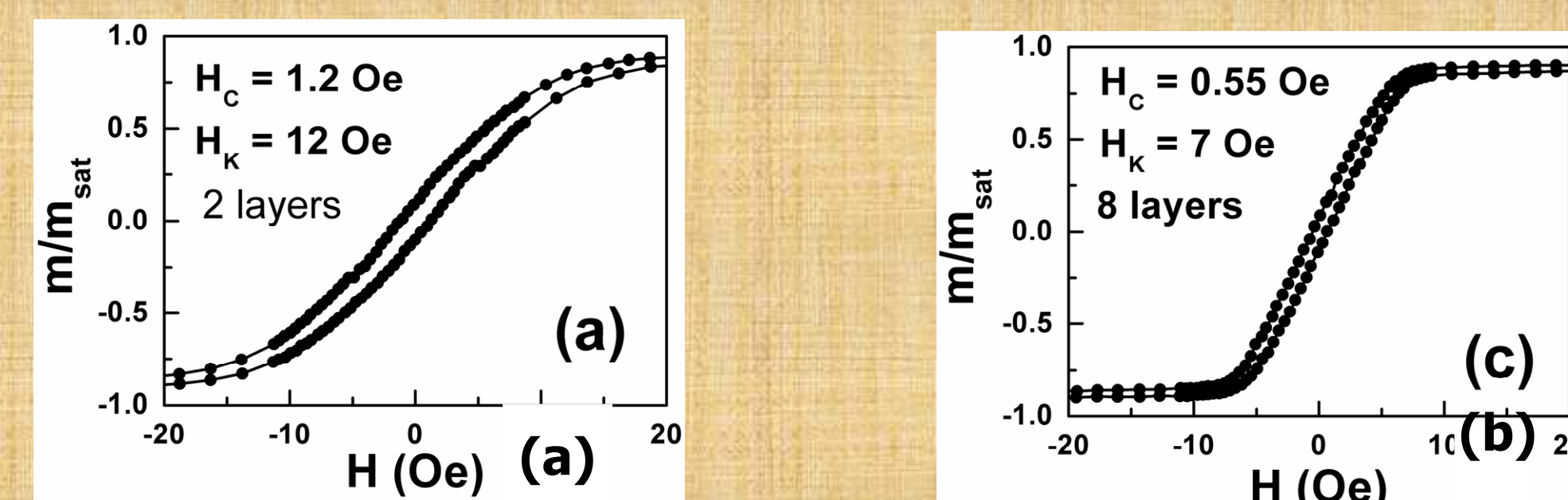


Figure 7. Hysteresis loops of Py samples with (a) 2 and (b) 8 layers with alternating perpendicular anisotropies and a t:2t thickness ratio. In both cases the total thickness is 150 nm.

Results

1. The effect of the sample thickness in the magnetic behaviour

The effect of the sample thickness can be seen in figure 2. These loops exhibit quite different behaviour changing from an in-plane anisotropy for the thinner to a clear perpendicular to the plane anisotropy for the others. MFM measurements on the thicker samples (Fig 1) show a stripe domain pattern that proves the existence of an anisotropy perpendicular to the sample plane.

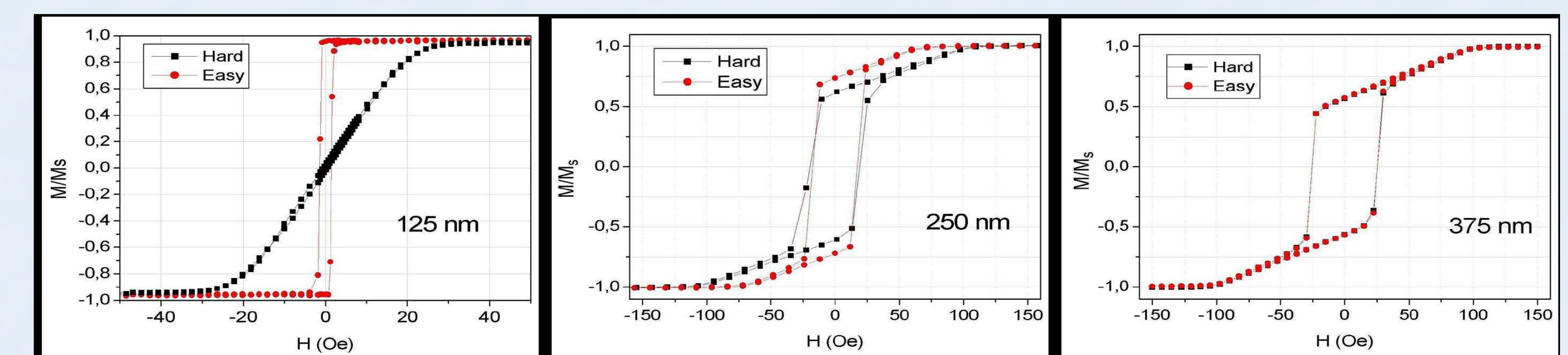


Fig 2: Py hysteresis loops for film thicknesses (a)125, (b)250 and (c)375 nm

2. The effect of the Molibdenum spacer

Figure 3 shows that a thin Mo spacer of 10 nm results enough to break the magnetic coupling between the Py layers and the columnar morphology, maintaining the anisotropy in the plane. Hysteresis loops in Figure 4 shows coercive and saturating fields much lower than those obtained in a Py monolayer with the same thickness (Figure 2b).

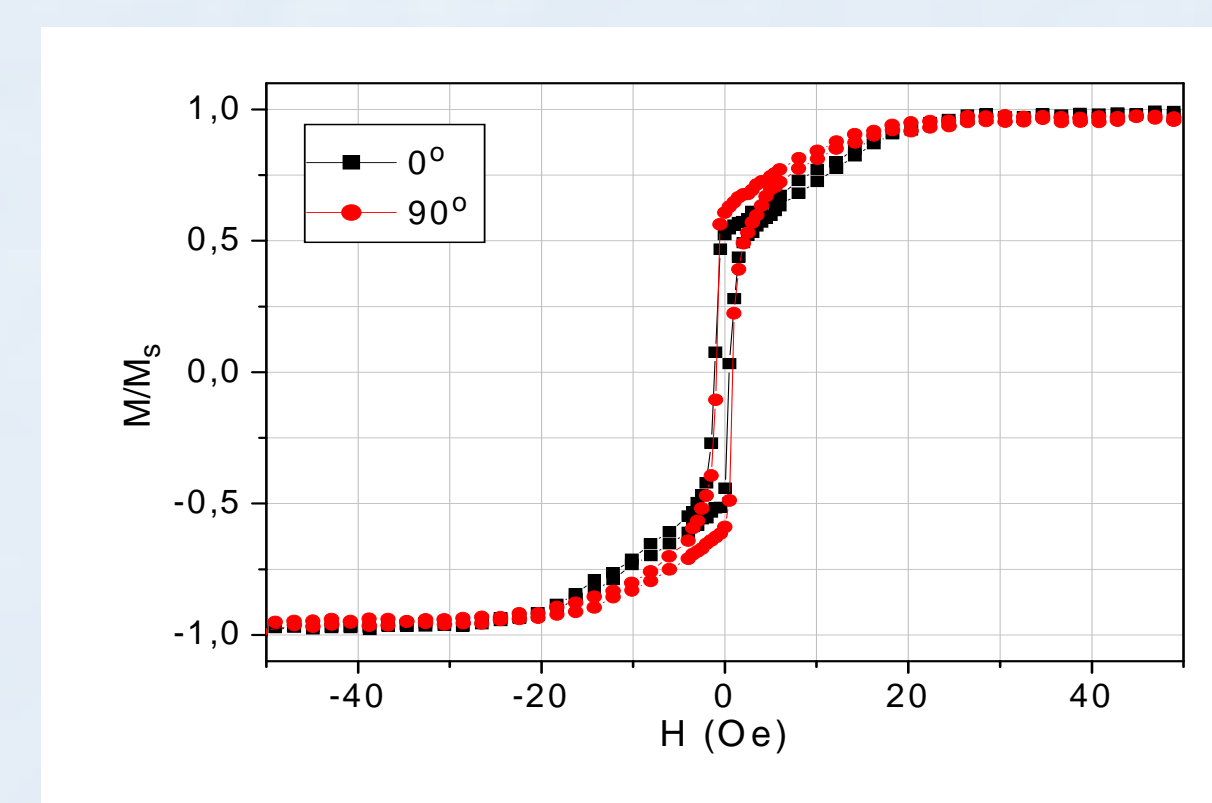


Fig 3: Py/Mo/Py hysteresis loop with perpendicular anisotropies.

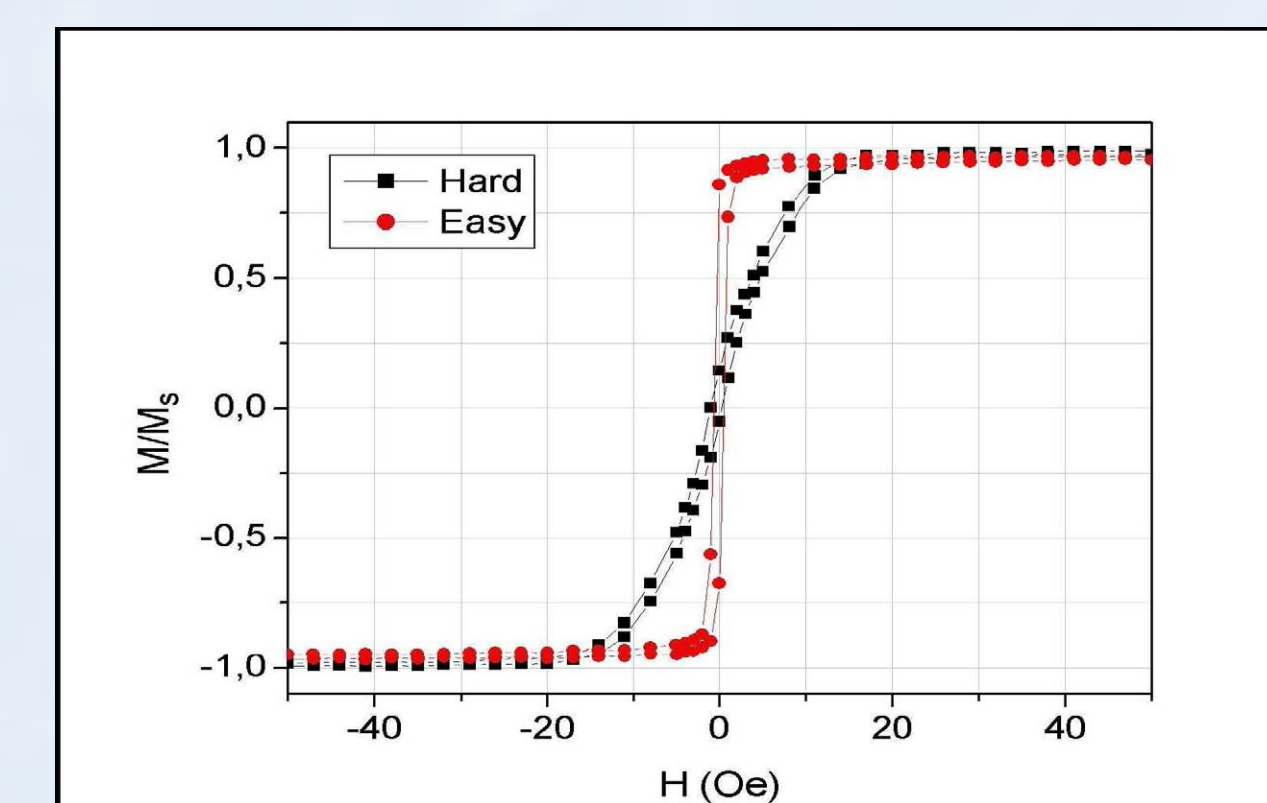


Fig 4: Hysteresis loop of a multilayer consisting in 4 Py layers separated by 10 nm Mo spacers. The total Py thickness is 250 nm.

3. The effect of the thickness in the coercive field of Py/Mo multilayers

Figure 5 shows the effect of the thickness in the coercive field of Py/Mo multilayers. A minimum in the coercivity was found for Py layer thicknesses corresponding to 30 nm. This minimum coincides with the transition thickness of a single film where Bloch domain walls change to Néel domain walls. The width of Bloch domain walls increases as the Py thickness increases and the width of the Néel walls core increases as the Py thickness decreases. This fact makes the coercivity have the same behavior (increase) when the Py layer is thicker or thinner than 30 nm.

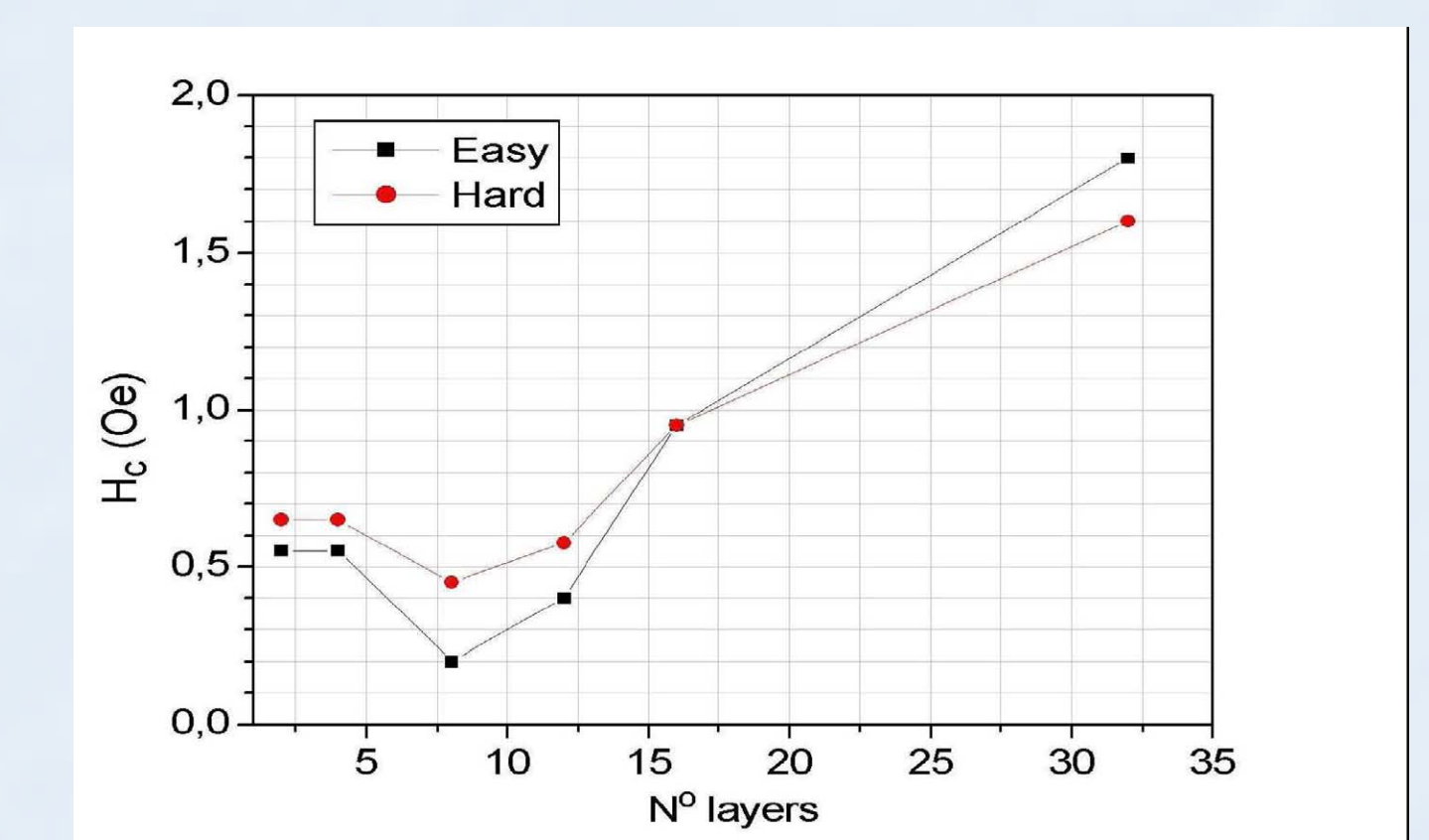


Fig 5: Coercive fields of a Py/Mo multilayer with a total thickness of 250 nm as a function of the number of Py layers

Conclusions:

It is observed how the soft magnetic properties of sputtered Py films can be maintained for thicknesses over 180 nm by growing samples as multilayers with thin Mo spacers. The coercivity can be minimized for particular Py thicknesses about 30nm.

References:

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